

(19) World Intellectual Property Organization  
International Bureau



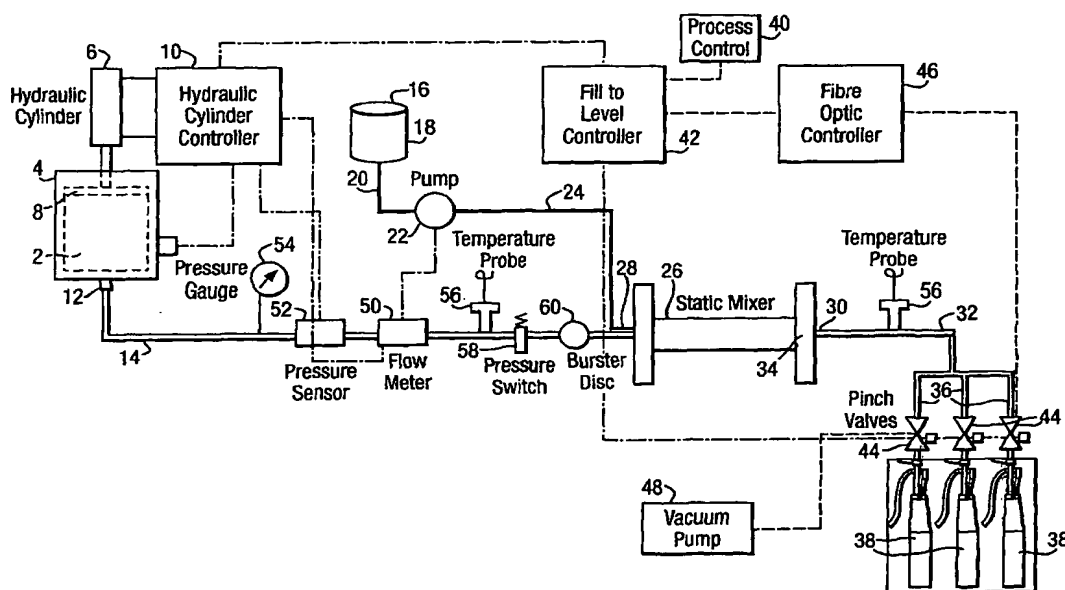
(43) International Publication Date  
25 September 2003 (25.09.2003)

PCT

(10) International Publication Number  
**WO 03/078356 A1**

- (51) International Patent Classification<sup>7</sup>: **C06B 21/00**
- (21) International Application Number: **PCT/GB03/00954**
- (22) International Filing Date: **6 March 2003 (06.03.2003)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:  
**0205559.8**      **11 March 2002 (11.03.2002)**      **GB**
- (71) Applicant (for all designated States except US): **BAE SYSTEMS PLC** [GB/GB]; 6 Carlton Gardens, London SW1Y 5AD (GB).
- (72) Inventors; and  
(75) Inventors/Applicants (for US only): **PRESSLEY, Malcolm** [GB/GB]; Bae Systems RO Defence, Glascoed, Usk, Gwent NP15 1XL (GB). **BASTOW, Colin, Henry** [GB/GB]; Bae Systems RO Defence, Glascoed, Usk, Gwent NP15 1XL (GB). **HICKS, Graham** [GB/GB]; Bae Systems RO Defence, Glascoed, Usk, Gwent NP15 1XL (GB).
- (74) Agent: **BAE SYSTEMS PLC**; Group IP Department, Lancaster House, P.O. Box 87, Farnborough Aerospace Centre, Farnborough, Hampshire GU14 6YU (GB).
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:**  
— with international search report
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS FOR MIXING EXPLOSIVE MATERIALS AND FOR FILLING OF ORDNANCE



(57) Abstract: Described herein is apparatus for the mixing of explosive materials utilising a static mixer (26) for combining pre-mix explosive material and hardener prior to introducing the combined mixture into any ordnance (38).

## APPARATUS FOR MIXING EXPLOSIVE MATERIALS AND FOR FILLING OF ORDNANCE

This invention relates to the field of the filling of ordnance with explosive materials, and more specifically to the use of static mixing in the filling process.

5        Traditional methods used for filling ordnance with polymer bonded explosive (PBX) utilise a filling process based on the combination of usually two materials, namely an explosive mixture (pre-mix) and hardener, which are mixed together immediately prior to use in filling the chosen ordnance.

10       In a typical application of the mixing and filling process, a pre-mix of explosive such as for example PBX is produced and typically mixed with a hardener (i.e. IPDI) the combined mixture being mixed together in a high shear mixer.

15       Once mixed, the bowl of the high shear mixer containing the fully mixed PBX composition is fitted with a pressure plate apparatus and cover, then raised to an appropriate filling height on a specialised bowl lift.

      Once elevated into position, the bowl of fully mixed PBX composition is pressurised using an inert gas (i.e. nitrogen) for the purposes of aiding the dispensing of the fully mixed PBX composition through a system of pipes to the ordnance filling position.

20       Ordnance to be filled is typically placed in a vacuum chamber and a filling attachment from the bottom outlet valve of the mixer bowl containing the fully mixed PBX composition is attached to the chamber. Typically the vacuum will be evacuated to <100 millibars.

25       The vacuum provides the physical motivation for the fully mixed PBX composition to flow into the ordnance when the valve from the bottom outlet of the mixer bowl is released. The quantity of fully mixed PBX composition introduced to the cavity within the ordnance is usually judged visually, and when sufficiently filled the vacuum to the chamber is released and the filled component removed ready for the introduction of the next ordnance component  
30       to be filled.

- 2 -

The traditional method of filling ordnance as described above suffers from a number of problems associated with the finite 'pot life' time of the fully mixed PBX composition and the fact that once the various chemicals have been combined the 'pot life' time defines the period within which the filling process must be completed before the PBX composition cures and can no longer be used in the process (i.e. would solidify within the pipe work).

The 'pot life' is typically in the order of two hours and in instances where there are no problems associated with a particular batch of components, then the mixing of PBX and hardener (IPDI) in a bowl and the subsequent dispensing of the fully mixed PBX composition into ordnance can be achieved relatively quickly. However, if for any reason (for example mechanical breakdown etc) the filling process has to be interrupted or indeed suspended, then the whole of the fully mixed PBX composition has to be purged from the mixing and filling apparatus, the purged material being lost to waste.

The invention described herein provides for apparatus and a method for the mixing of explosive compositions and the subsequent filling of ordnance without being subject to the problems associated with having to mix and use a specific quantity of explosive composition within a limited 'pot life' period.

Accordingly there is provided apparatus for the mixing of explosive materials, comprising:

a reservoir of pre-mixed explosive material,

a reservoir of hardener material,

a static mixer means,

each of said reservoirs having pipe means for conveying said pre-mix explosive material and hardener material respectively into the inlet of a static mixer means, the outlet of said static mixer means being connected to means for effecting the filling of ordnance components.

Preferably the pipe means for conveying each of said materials are not linked or combined until they reach the inlet of said static mixer means.

- 3 -

Preferably the means for filling each of said ordnance components with said final mixed explosive material will be controlled such that the respective pre-mix explosive material and the hardener materials are introduced to the static mixer means on demand, thereby minimising the amount of combined  
5 explosive material in said apparatus to that contained in the static mixer means itself and the associated pipe-work used to connect the output of said static mixer unit to the ordnance for filling.

The invention is now described by way of example only with reference to the following drawing in which Figure 1 is a diagrammatic representation of an  
10 explosive mixing and ordnance filling apparatus in accordance with the invention.

Figure 1 shows a pre-mix explosive material 2 is shown in a high shear mixing bowl assembly 4 wherein the mixing of the pre-mix explosive material 2 has been completed, the pre-mix explosive material 2 being held within the  
15 mixing bowl 4 subjected to controlled pressure by the action of a hydraulic cylinder 6 and ram 8 assembly. Hydraulic cylinder control means 10 is shown for controlling the flow of pre-mix explosive material 2 through the exit valve 12 and onwards through the pre-mix explosive material pipe work 14.

Hardener material 16 is depicted housed within a header tank 18 having  
20 pipe work 20 leading to a pump means 22 to provide the controlled supply of hardener material 16 through the pipe work 24.

A static mixer means 26 is provided having pipe work 14 and 24 at its inlet port 28 and an outlet port 30 and corresponding pipe work 32 for conveying final mixed explosive material 34 to ordnance filling stations 36.

25 In use, ordnance 38 to be filled with final mixed explosive composition 34 are positioned at ordnance filling stations 36. When the ordnance is correctly in position 38 and the associated fill-to-level control apparatus is connected (not shown). A signal from the process control 40 to initiate the filling operation is activated. A demand signal is received by the fill-to-level controller 42 from the  
30 non-contact level sensor 46 indicating that the ordnance is not filled and accordingly the fill-to-level controller 42 sends a demand signal to the pre-mix

- 4 -

explosive material hydraulic cylinder controller 10 and the hardener material pump 22.

The pre-mix explosive material 2 and hardener material 16 are conveyed through their respective separate pipe works 12, 24, both materials 2, 16 being introduced individually to the inlet 28 of the static mixer means 26. It is important to note at this point that in accordance with the invention the point at which the pre-mix explosive material 2 and hardener material 16 are first combined is substantially at the inlet port 28 of the static mixer means 26 thereby providing a distinguishing feature over the prior art in which the two materials are normally combined in the mixing bowl, thereby starting the 'pot life' for the combined explosive material within the mixing bowl 4.

At the inlet 28 of the static mixer means 26 the pre-mix explosive material 2 and hardener material 16 are forced through a number of static mixing blade means 4, thereby mixing the two materials 2, 16 together. Such static mixing means are known within the confectionery and food industries and typically comprise a plurality of blade means arranged in a 'corkscrew' type manner which promotes the effective mixing together of two or more materials when forced through the mixer.

Additionally, the use of a static mixing means provides for simplified cleaning of the apparatus following the completion of an ordnance filling run, thereby further reducing the inherent complexity and time required for purging and cleaning using state of the art apparatus.

The combined final explosive mixture 34 passes through the static mixer means exit port 30 and along the pipe-work 32 arriving at the ordnance filling stations 36. At the filling stations 36 the flow of combined explosive mixture 34 into the waiting ordnance 38 is controlled via pinch valves 44, the operation of said pinch valves 44 being controlled so as to limit the volume of combined final explosive mixture 34 introduced into the ordnance 38. A vacuum source 48 is provided to encourage the filling of the volume within the ordnance.

The control of the valves 44 (typically pinch valves) to enable the accurate filling of the ordnance may be effected either by a human operator

- 5 -

directly controlling a valve 44 or by a mechanised system, which for the purposes of this specific embodiment utilises a non-contact level controller 46 which forms part of an integrated control system 10, 40, 42, 46, 48.

When the non-contact level controller 46 senses that ordnance 38  
5 requires filling with combined final explosive mix 34, then a signal is sent to the fill-to-level controller 42 which in turn initiates the flow of both pre-mix explosive material 2 and hardener material 16 through the static mixing means 42 and via the outlet pipe work into the waiting ordnance 38. When the non-contact level controller 46 senses that any of the ordnance 38 has reached its fill limit, then a  
10 signal is sent to the fill-to-level controller 2 to stop the flow of materials 2 and 16.

The non-contact level controller 46 may comprise an optical sensor, a fibre optic sensor, a laser sensor or an LED sensor.

Using the above stated control means thereby provides for both  
15 apparatus and a method of filling ordnance 38 with combined final explosive mixture 34 in a controlled manner, utilising apparatus that prolongs the 'pot life' of said combined final explosive material 34. This resulting in significantly less waste explosive material to be disposed of and additionally simplifies the cleaning of the system by minimising the number of elements of the apparatus  
20 actually exposed to combined final explosive material 34. The method of filling ordnance 38 using such apparatus and control means can provide an automated ordnance filling system.

In order to clean the apparatus as described, the action of pumping pre-mix explosive material 2 (or an alternative compatible inert material) through the  
25 apparatus in the absence of any hardener material 16 will be substantially sufficient to purge the system of any combined final explosive material 34, thereby reducing the complexity, time and danger level associated with purging state of the art apparatus within which combined final explosive material has been allowed to cure.

30 In addition to the elements described in the specific embodiment of the invention, a number of measuring sensors and safety devices would also be

- 6 -

incorporated into the apparatus as shown in Figure 1, namely a flow meter sensor 50, a pressure sensor 52, temperature probes 56, a pressure switch 58 and a safety burst disc 60. Such sensors and safety devices are known in the art and are included in the specific embodiment by way of example to illustrate  
5 the industrial application of the invention.

Additionally, a colour agent or dye can be added to the hardener material 16 such that it will be possible to monitor the amount of hardener 16 present in the final combined explosive mixture 34. The analysis of the colour of the combined mixture 34 may be made by utilising a colour sensor means located  
10 after the mixing process calibrated to recognise particular ranges of colour as indicating sufficient percentage of hardener in the combined material 34, or by use of a viewing window in the pipe work containing the combined mixture 34 to allow for visual inspection of the colour of said mixture 34.

It is to be noted that the hydraulic cylinder 6 and ram 8 assembly is far  
15 safer than using displacement pumps to pump the pre-mix explosive material to the static mixer 26. It is also to be noted that the pre-mix explosive material is not pumped to the static mixer as this may be too dangerous.

As an alternative to the flow meter 50 being located in the pre-mix explosive material pipe work 14, the flow meter may be located in the hydraulic  
20 line to the hydraulic ram 8. In this case, the flow meter accurately measures the displacement of the ram 8 and hence the mass flow of the pre-mix explosive mixture. This alternative is of particular use when the pre-mix explosive material is too viscous and inaccurate flow readings are obtained when the flow meter is in the pre-mix explosive material pipe work 14.

25 Other advantages of the invention will be readily apparent to those skilled in the art and the substitution of elements for mechanical equivalents and adaptation of the process using different materials and the like should be construed as being comprised within in the inventive concept as claimed.

References to ordnance in the above specification and claims shall be  
30 construed as non-limiting and in respect of the invention shall include without limitation shells, mortars, rockets, projectiles and any other ordnance or

- 7 -

containers which are required to be filled with a combined final explosive mixture.



- 8 -

CLAIMS

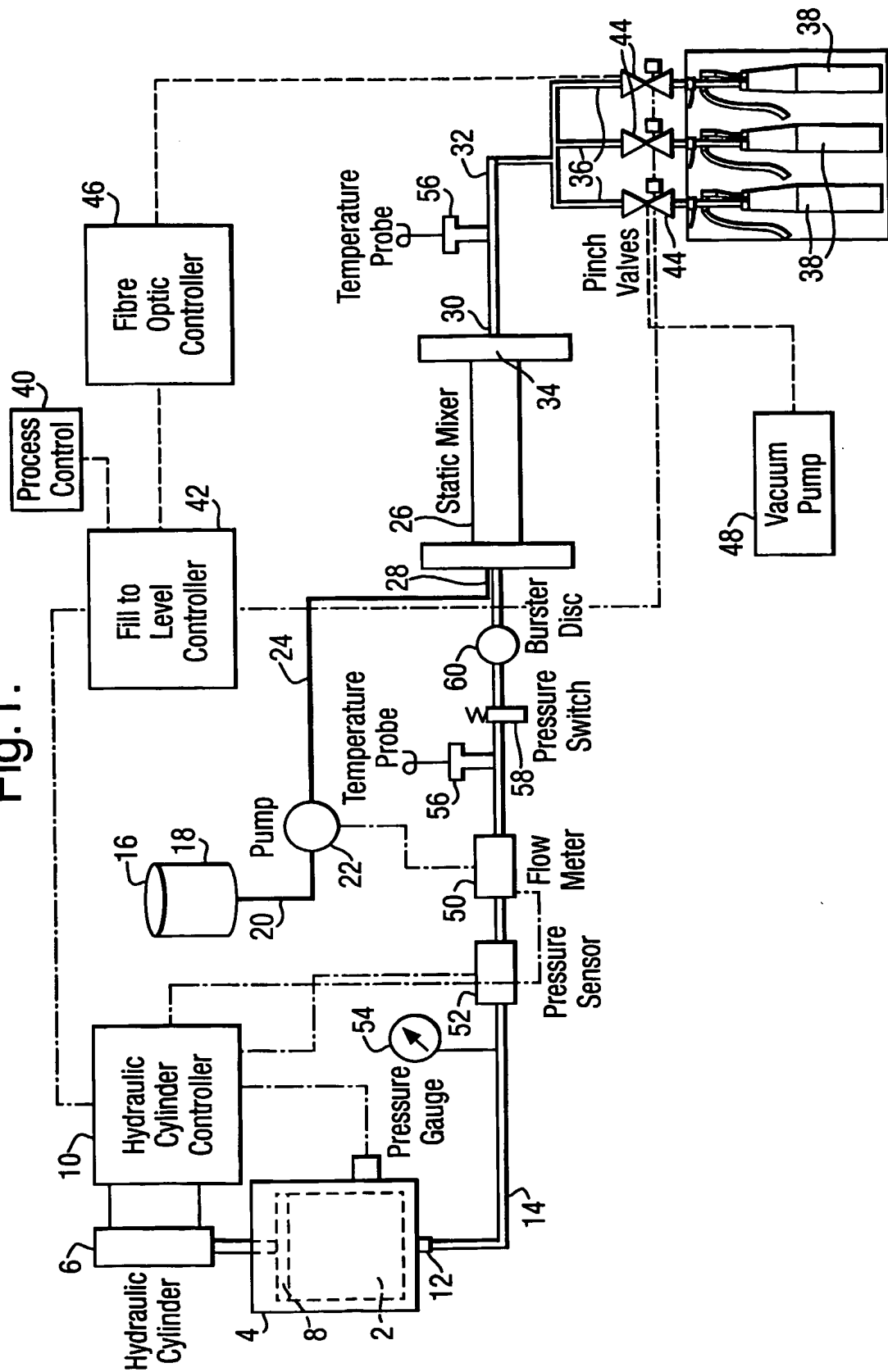
1. Apparatus for the mixing of explosive materials, comprising:  
  
a reservoir of pre- mixed explosive material,  
a reservoir of hardener material,  
5 a static mixer means,  
each of said reservoirs having separate pipe means for conveying said  
pre-cure explosive material and hardener material respectively to a static  
mixer means.
2. Apparatus for the mixing of explosive materials in accordance with claim  
10 1, wherein said materials are combined substantially at the inlet of said  
static mixer means.
3. Apparatus for the mixing of explosive materials in accordance with claim 1  
or claim 2, wherein the outlet of said static mixer means is connected to  
means for effecting the filling of ordnance.
- 15 4. Apparatus for the mixing of explosive materials in accordance with any of  
claims 1, 2 or 3 wherein the means for filling each of said ordnance  
components with said combined final explosive material is controlled such  
that the respective pre-mix explosive material and hardener materials are  
introduced to the static mixer means on demand, the demand controlled  
20 by an automated ordnance fill level control means.
5. Apparatus for the mixing of explosive materials in accordance with any of  
claims 1 to 4 wherein said fill-to-level control means comprises at least  
one fibre optic sensor.
6. A method for the mixing of explosive materials utilising apparatus in  
25 accordance with any of claims 1 to 5.
7. A method for the mixing of explosive materials in accordance with claim 6,  
wherein the output from said static mixer is connected to apparatus for the  
filling of ordnance with explosive materials.

- 9 -

8. Apparatus for the mixing of explosive materials substantially as hereinbefore described with reference to the accompanying drawings.
9. A method for the mixing of explosive materials substantially as hereinbefore described with reference to the accompanying drawings.

1/1

Fig.1.



## INTERNATIONAL SEARCH REPORT

Internat. Application No.

PCT/JP 03/00954

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 C06B21/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C06B F42B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 41 15 201 A (REINHARDT-TECHNIK GMBH & CO.) 9 January 1992 (1992-01-09)	1-3,8
Y	column 1, line 17 - line 33 column 3, line 1 - line 11; claims; figure 1	4-7,9
X	US 4 191 480 A (H. HIORTH) 4 March 1980 (1980-03-04) column 1, line 7 - line 13 column 2, line 3 - line 41 column 4, line 45 - line 54; claims	1-3,8
Y	US 5 114 630 A (K.E. NEWMAN ET AL.) 19 May 1992 (1992-05-19) column 2, line 8 - column 6, line 13; claims column 8, line 51 - line 55	4-7,9
	--- -/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

## \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the international search

1 July 2003

Date of mailing of the international search report

09/07/2003

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Schut, R

## INTERNATIONAL SEARCH REPORT

International Publication No.

PCT/GB 93/00954

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FR 2 225 979 A (ETAT FRANCAIS) 8 November 1974 (1974-11-08) page 5, line 11 - line 18; example 1 ----	6,7,9
Y	US 5 074 937 A (B.A. STOTT ET AL.) 24 December 1991 (1991-12-24) claims -----	6,7,9
Y	GB 1 605 257 A (AEROJET-GENERAL CORPORATION) 24 September 1986 (1986-09-24) page 11, line 26 - line 53 -----	6,7,9

# INTERNATIONAL SEARCH REPORT

Internat. Application No.

PCT/JP 93/00954

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE 4115201	A	09-01-1992	DE 9005388 U1 DE 4115201 A1	23-08-1990 09-01-1992
US 4191480	A	04-03-1980	NO 771200 A CA 1092599 A1 DE 2813865 A1 ES 468489 A1 GB 1598107 A JP 1139875 C JP 54000264 A JP 57031444 B SE 426388 B SE 7803236 A ZA 7801650 A	05-10-1978 30-12-1980 19-10-1978 01-01-1979 16-09-1981 24-03-1983 05-01-1979 05-07-1982 17-01-1983 05-10-1978 28-03-1979
US 5114630	A	19-05-1992	NONE	
FR 2225979	A	08-11-1974	FR 2225979 A5	08-11-1974
US 5074937	A	24-12-1991	NONE	
GB 1605257	A	24-09-1986	DE 1446902 C1	24-05-1984